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APPLICATION AND USE OF URINE IN TEXTILES – AN OVERVIEW

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ABSTRACT

The raw material used in utmost quantity in almost every stage of textile wet processing is water. Water is not economical to buy, treat and dispose. If industry does not have water conservation program, industry is pouring money down the drain. On the other hands many metropolitan cities and public places restrooms draining collected human urine. Human urine has the potential to be used as a solvent in textile wet processing.

By following certain necessary recommendations for storage and reuse, which are depend on the type of wet processing, it is possible to collect, store and utilize human urine in textile wet processing.

To promote urine valorization can solve three major social, environmental and economical problems: minimize peeing against wall and tree in public, limitation of environmental pollution because of urination and it may add income to public restrooms authorities by supplying urine as per requirement.

To encourage research and applications about use of urine in textile wet processing can be helpful in the 'Swachh Bharat Abhiyan' - a massive mass movement that seeks to create a Clean India.

KEYWORDS: Swachh Bharat Abhiyan, Urine, Fermentation Vat, Pathogen and Mordants

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Original Article

INTRODUCTION

The raw material used in utmost quantity in almost every stage of textile wet processing is water. [1,2] It is fact that, in a textile processing plant, water is a crucial raw material not only for the boilers supplying steam for heating and drying purpose, but also for all the wet processes such as scouring, bleaching, dyeing, printing and finishing. Water is a essential natural reserve for sustaining life and environment, which is always thought to be available in profusion and free gift of nature. Nowadays water shortage is becoming a global concern. Due to boost in industrialization, the water quality and quantity both are now on the edge of getting depleted.

Water is costly to buy, treat, and dispose. If industry does not have water conservation program, industry is pouring money down the drain[3.] Reusing of textile wastewater is in general based on some sorts of wastewater treatment process before reusing [4.] Similarly there are many operations in the wet processing industry which doesn't require water of drinking quality but all water used in the industry is of drinking water standard which requires expensive treatments.[3]It is possible to find out waste streams like human urine which can be use in textile processing.

URINE

Urine is a liquid by-product of metabolism in the bodies of many animals as well as humans.

It is excluded from the kidneys and flows through the ureters to the urinary bladder, from which it

Is soon excreted from the body through the urethra during urination. [5]

Human urine does not generally contain pathogens that can be transmitted through the environment. Basically urine is

A pathogen-free mixture. [6-11]

Food consists of various organic chemicals which release chemical energy during digestion. Proteins and carbohydrates like larger organic chemicals, are broken down into smaller components and the resultant wastes are excreted. The majority of the nutrients including nitrogen, phosphorus, and potassium which are predominately water-soluble are shed from the body in the form of urine. The kidneys balance the diverse elements in blood, extracting excess amounts of imperative substances and water in the form of urine. Urine contains minerals, vitamins, hormones, proteins, enzymes, hormones, antibodies as well as amino acids. [12, 13]

Urine is a clean product if not contaminated by faeces. Urine, like other body fluids, can be either acidic or alkaline. Urine normally is slightly acid, with a pH around 6, although it can range from 4.5 to 8. Urine pH changes, depending on diet, certain disease processes and the medications. Excreting acid or alkaline urine helps maintain the body's acid-base balance, the balance between acidity and alkalinity. Vegetarians generally have more alkaline urine than meat eaters, because meat and dairy produce acidic urine and most vegetables and fruits a more alkaline urine. [14-65]

Solutes in Urine

More or less 95% of the volume of normal urine is due to water. The other 5% consists of solutes element that are dissolved in the water. Some of these solutes are the outcome of normal biochemical activity within the cells of the body. Other solutes may be due to chemicals that originated outside of the body, in particular pharmaceutical drugs. These solutes can be split into two categories according to their chemical structure (e.g. size and electrical charge).

Organic Molecules

Organic molecules are electrically neutral and can be relatively large (compared with the 'simpler' ions - below). These include:

Urea

Urea is an organic (i.e. carbon-based) compound having chemical formula is: CON_2H_4 or $(NH_2)_2CO$ and also known as carbamide. Urea is derived from ammonia and formed by the deamination of amino acids. The amount of urea in urine is depend on quantity of dietary protein.

Creatinine

Creatinine is a normal (healthy) ingredient of blood. It is produced mostly as a result of the breakdown of creatine phosphate in muscle tissue. It is generally produced by the body at a fairly constant rate (which depends on the muscle mass of the body).

Uric Acid

Uric acid is an organic (i.e. carbon-based) compound having chemical formula is: C5H4N4O3. Because of its insolubility, uric acid has a tendency to crystallize, and is a common part of kidney stones.

Other Substances/Molecules

Example of other substances that may be found in small amounts in ordinary urine include enzymes, carbohydrates, pigments, fatty acids, hormones, and mucins (a group of large, heavily glycosylated proteins found in the body).

Ions

Even in the cases of ions formed by groups of atoms (they are ions owing to the few lost or gained electrons), the groups are formed from only a small number of particles and hence tend to be relatively small. These include:

Individual Elements

Sodium (Na+)

Amount in urine alters with diet and the amount of aldosterone (a steroid hormone) in the body.

Potassium (K+)

Amount in urine alters with diet and the amount of aldosterone (a steroid hormone) in the body.

Chloride (Cl-)

Amount in urine alters with dietart intake (chloride is a part of common salt, NaCl).

Magnesium (Mg2+)

Amount in urine alters with diet and the amount of parathyroid hormone in the body. (Parathyroid hormone increases the reabsorption of magnesium by the body, which may decreases the quantity of magnesium in urine.)

Calcium (Ca2+)

Amount in urine alters with diet and the amount of parathyroid hormone in the body. (Parathyroid hormone increases the reabsorption of calcium by the body, which may decreases the quantity of calcium in urine.)

Small Groups Formed from a Few Different Elements

Ammonium (NH4+)

The amount of ammonia produced by the kidneys may alters according to the pH of the blood and tissues in the body.

Sulphates (SO42-)

Sulphates are derivative of amino acids. The quantity of sulphates excreted in urine alters according to the quantity and type of protein in the person's diet.

Phosphates (H2PO4-, HPO42-, PO43-)

Amount in urine alters with the amount of parathyroid hormone in the body, which increases the quantity of phosphates in urine. 66

Physical Characteristic of Urine

Typical physical characteristic of urine are noted in Table 1. [67]

Table 1: Physical Characteristic of Normal Urine

Characteristic	Description
Volume	1-2 L in 24 Hours but varies considerably.
Colour	Yellow or amber but varies with concentration and diet. Color is due to urochrome (pigment produced from breakdown of bile).
Turbidity	Transparent when freshly voided but become turbid (cloudy) upon standing due to urea hydrolysis and subsequent precipitation.
Odor	Aromatic but becomes ammonia-like upon standing due to urea hydrolysis.
pH	Ranges between 4.6 and 8.0; average 6.0; varies considerably with diet. High-protein diets increase acidity; vegetarian diet increases alkalinity.
Specific gravity	It ranges from 1.001 to 1.035. The higher the concentration of solute, the higher the specific gravity.

The amount of urine produced by a person is depends on the amount of liquid drinks by that person, but usually it is within a range of 0.8 to 1.5 L per day for an adult person and about half as much for children, respectively (WHO 2006).[105]

URINE AS AN VALUABLE COMMODITY: AN HISTORICAL OVERVIEW

The saying goes that one person's urine waste is another's treasure. Today we flush or urine away without giving it a second thought, but in ancient times it was considered a valuable commodity. A quick look back in history shows that Ancient Romans valued urine so much so that they, like all valuable products, there was a scheme to tax it. The Roman Emperor Vespasian taxed the trade of urine—which was valued for its ammonia content—from public restrooms. [68 – 71.] Ancient laundries used a giant clay pots which were placed out in public for people to relieve themselves and to collect urine. Ultimately, so much urine was used and collected that a tax was forced by the Roman emperor. *Pecunia non olet* meaning, "money does not stink" was a famous saying coined as a result of this tax levied by the emperors Nero and Vespasian in the 1st century AD. [70] The phrase *Pecunia non olet* is still used today to say that the value of money is not infected by its origins. Vespasian's name still attaches to community urinals in France (*vespasiennes*), Italy (*vespasiani*), and Romania (*vespasiene*). [72-75]

APPLICATION AND USE OF URINE

Various Application and Use of Urine in Textiles are as Follows

Urine for Fabric Cleaning and to Make Fabric Bright and Colourful

A toga is the draped, dress-like garment worn by the citizens of ancient Rome.[78-87] The toga as the Roman national dress was allowed to be worn by free citizens only. [88] Ancient Romans used urine to make their togas bright and colourful. The ammonia in urine was used to clean togas in a place called a fullery. The first stage of cleaning involved men jumping up and down on the togas in large vats with urine inside, like living washing machine agitators, while the second stage

often included dirt or ash. Both helped dissolve grease that accumulated on the togas and made them bright again.[77] The ammonia in the urine remove stains, which is why Romans used to clean clothing.

Urine for Textile Bleaching

Historically, urine has had a numeral of uses, and laundry is only one of them. People have done bleaching using urine.. The process to using urine for bleaching is allowing it to stand, encouraging the development of ammonia by allowing the urine to react to the air. The resulting ammonia is the cleaning agent, instead of the urine itself. Once ammonia has developed, small amounts of the liquid can be used to treat spots and stains or garments can be dipped in the urine for cleaning.

In case of wool, people used to poured stale urine over wool in a large vat and walked as well as agitate it and allowing the urine to penetrate to clean it. When laundries used urine for bleaching, it was a somewhat stinky process.

The urine had to be allowed to keep in vats for weeks to develop the necessary ammonia levels, and it could leave an unlikable odor behind after it was used as a cleaner. Many cleaners today continue to use ammonia-based products, while they are not generally derived from urine.[106]

Urine Makes Wool Extraordinarily Soft to the Touch

Urine acts as a cleansing agent, removing oils and dirt, particularly important in preparing wool for dyeing. Once dried, the resultant wool, is not only much cleaner, but also extraordinary soft to touch. [93]

Urine as an Extracting Agent

Certain natural substances, when soaked in old urine, will give up a highly valued and highly useable pigmentation. For example, fermenting the lichen orchil in stale urine will yield a lovely purple coloration that can then be used to die wool and cotton.[93, 94, 95, 96] The techniques and knowledge for making orchil lichen dyes were massive secrets in early times. The most primitive known description of the preparation of orchil was given by Roseto in 1540. The process generally consisted of obtaining the preferred lichen, adding it to old urine and slaked lime, and waiting. If the fermentation process occurred for too long, the color would destroy. Some of the dyes even produced a distinguishing smell of violets that was typical of orchil. It was also revealed that by adjusting the alkalinity, different shades of color could be produced. [97]

Urine as a Dying Medium and Fixative

Dye recipes used urine. However, old recipes don't mention it. It was like water. Stale urine has different properties than fresh urine. "Stale" being urine that's been sitting around in a vat waiting to be used.[98] Many natural dyes require the use of chemicals called mordants to bind the dye to the textile fibres; tannin from oak galls, salt, natural alum, vinegar, and ammonia from stale urine were used by early dyers. [99-100] Traditionally a fermentation vat was used to dye with woad, usually started with stale urine. For making the woad soluble, the fermentation removes the oxygen from the vat. Wool or fabric dipped into the vat for a few minutes and then removed. At first the wool look pale yellow, but with exposure to air, the colour little by little turns to green and then to blue. Repetitive dipping create a darker and darker blue. [101, 110.] By 1200, Europe imported alum from North Africa and Sicily and used as a mordant for fixing the colours in woolen cloth. The purpose of the mordant is to help the dye in sticking to the material. It also improves the durability, colorfastness and light fastness of the dye itself. The tone of the colour of the dye is found to be changed by application of

some mordants.. For darken colors or to tone down brightness Iron was used and was often used as a post-dye bath. Ammonia, readily available in the form of stale urine, was a key component in processing woad. Ammonia which is available in stale urine was also used to adjust the acidity levels which alters colors in various dyes, like madder.[102] In medieval Europe, Lichen acids were the source of important dyes for cotton and wool. Lichen dyes first dissolved in human urine, and then the yarns were immersed in this mixture. Ammonia salts in the urine acted as mordants to make the dyes permanent. [103]

Various Application and use of Urine Other than Textiles are as Follows

Urine for Medicine

Buddhist Monks were using fermented cows urine for medicine.[104] Urine has been used in various ways as a healing substance, both when taken internally and when applied externally. Native Eskimo people are but one of many cultures were using fresh urine as an antiseptic, and certain tribes of central Africa who mix it with mud in order to form a paste which relieves insect bites. [93]

Urine as a Teeth Whitener

Urine contains a extensive array of vital minerals and chemicals such as phosphorus and potassium. The Romans assumed that urine would make their teeth whiter and keep them from decaying so they used it as a mouthwash and mixed it with pumice to make toothpaste. Urine was so effective that it was used in toothpastes and mouthwashes up until the 1700s. As far as the Romans were concerned, the best and therefore the most costly urine on the market came from the country of Portugal. It was apparently the strongest urine in the world and thus, the choice for whitening teeth. [70, 75, 76, 77]

Urine for Tanning Leather

Ancient Romans were using urine for tanning leather. The Romans frequently employed urine, dog feces, and sometimes human feces in tanning—no, not for sunning themselves outside, but for making leather. A good long soak in urine would help remove hair from the pelt, and then feces were ground into it, sometimes for hours at a time. The enzymes made by the bacteria in the feces softened the hide, making it more supple. [70, 77]

Growing Juicy Fruit

Urine also contains nitrogen and phosphorous, which are both useful for growing plants. The Roman author Columella wrote that old human urine was particularly useful for growing pomegranates, making them juicier and tastier. [77]

Curing Animal Disease

Sheep with bile issues were given human urine to drink, while those with lung issues were given urine through the nose. Sick bees could also be given human urine, and bird flu was cured by putting tepid urine on their beaks. [77]

Fertilizing Fields

The Romans did use human feces and urine in their gardens, as the organic portion of the solid waste from the body and the nitrates, phosphorous, and potassium of the urine nourished plants. [77]

Gunpowder from Urine

Gunpowder is a simple mixture of saltpeter, sulfur, and charcoal.[89] Saltpeter is the common name for potassium

nitrate (KNO3). Using urine is an old school method for manufacturing saltpeter. [90] Urine can be used in the manufacture of gunpowder. [92] This nitrate compound which allows gunpowder to rapidly oxidize and catch fire, generating an explosion that can be used to fire munitions. In the modern era, there are less smelly ways to obtain saltpeter, usually through an industrial process that uses ammonia as a base. [91]

Brain Cells

A few ingenuous scientists have found a way to make neurons out of human urine. [92]

CHALLENGES AND OPPORTUNITIES

Although there is evidence of using urine in textile wet processing but there is not much scientific study available. It may be because of easy availability of water in textile wet processing as well as production and development of various chemicals and auxiliaries which can be easily available on demand. The current and future challenge is to continue research on various uses of urine in textile and other fields.

The main difficulty and their probable solution about make use of urine in textile and other fields may be as follows.

Collection of Urine

Textile wet processing need lots of water and therefore if one thinking about replacement of water with urine, it is fact that urine should be available in adequate quantity. There are the highly crowded places across the cities and whole country which having public restrooms containing urinal facility. A train plays a big part in the life of every citizen of Mumbai and acts as a lifeline to the majority of people. There are various stations in the city that are more crowded than usual. The various railway stations records a footfall of passengers per day as denoted in table no. 2.

Table 2: Top Ten Busiest Stations in Mumbai Region

Sr No.	Railway Station	Approximately Footfall of Passengers Traveling Per Day (In Lakh)
1.	Thane	6.54
2.	Chhatrapati Shivaji Terminus Station (CST)	6.36
3.	Andheri Station	6.04
4.	Dadar Station	5.77
5.	Churchgate Station	5.05
6.	Bandra Station	4.91
7.	Virar Station	3.95
8.	Kurla Station	3.81
9.	Kalyan Station	3.60
10.	Nallasopara Station	3.25

Across the city there are many public places like educational institutes, theaters etc. which can be utilize for urine collection in large extent.

Urine Sanitation

It is possible to do sanitation of urine by various methods which are listed below.

Storage

During storage, urea is speedily converted to ammonia and increases the pH. The ammonia content together with the raise in pH has a sanitizing effect. Bacteria concentrations reduce quite quickly during storage, but prolonged storage is necessary in order to sufficiently reduce the number of viruses and protozoa. The urine should rather be stored undiluted. Concentrated urine provides a unsuitable environment for microorganisms, increasing the die-off rate of pathogens and also prevents breeding of mosquitoes. The urine should be enclosed in a sealed tank or container. This not only prevents humans and animals from coming in contact with the urine but also hinders evaporation of ammonia, decreasing the risk of odour and loss of nitrogen. In order to reduce the number of pathogens to "almost certainly none" it is suggested that urine is stored for 6 months at 20^{o}C. Temperature above 20^{o}C would possibly increase the inactivation of microorganisms. In addition to temperature, an proper storage time will depend on the size and health of the source group. A period of 6 months could be excessive, as some research suggests that urine stored for over one month may be found to be proper whilst remaining good enough for use.[108]

Very few pathogens are present in urine. Pathogens that do become introduced rapidly die off of in the high pH in urine collection tanks. Conclusions on health issues were that faecal contamination of the urine was limited. It was concluded that six months storage would be sufficient to destroy all pathogens. The pH of the urine increases from around 5 to 7 up to 8.8 to 9.2 on storage. [11]

Boiling

Excessive temperatures kill pathogens. The higher the temperature, the difficult it is for pathogens to survive. Boiling is an efficient way to make urine safe.108

UV+Heat

Sunlight has two synergetic mechanisms: radiation in the spectrum of UV-A as well as increased liquid temperature. UV irradiation damages DNA and hence inactivates pathogens. UV and heat will speed up the rate at which pathogens die-off in the urine.[108]

Chemical Additives

A chemical additive, for example, iodine (0.1 solution mix) will kill pathogens. [108]

Filters

Filters can be natural or artificial. A natural filter (e.g. sand), reduces pathogen levels by providing rivalry from other micro-organisms. But this is time consuming and success is unpredictable. An artificial filter (e.g. micromesh) works on the principle of reverse osmosis which is more efficient, but is very expensive. [108]

Flocculation

Flocculating agents attached themselves to patrhogens and hence allowing them to be filtered and collected. [108]

CONCLUSIONS

Human urine does not usually contain pathogens that will be transmitted through the environment.

The elevated pH (pH 9) caused by the conversion of urea to ammonium is advantageous for the inactivation of

microorganisms in the urine. Urine can be collected in large quantity by using urinals in various restrooms. After various process of sanitation urine can be use for textile wet processing. There are needed to take various research projects for study the various aspects about use of urine in textile wet processing. Textile wet processing can be perform at high temperature and hence we can say that it may not unsafe to use urine in textile wet processing whenever possible which can reduce demand of pure water and also having possibility to deliver an appropriate results. To encourage research and applications about use of urine in textile wet processing can be helpful to create more urinals in various restrooms across the city which can help in the 'Swachh Bharat Abhiyan' - a massive mass movement that seeks to create a Clean India.[109] To promote urine valorization can solve three major social, environmental and economical problems: minimize peeing against wall and tree in public, limitation of environmental pollution because of urination and it may add income to public restrooms authorities by supplying urine as per requirement.

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